Automotive Simulation Center Stuttgart - CAE + HPC Applications for the Automotive Industry

Prof. Dr.-Ing. Erich Schelkle
Automotive Simulation Center Stuttgart e.V.

Contents

- asc(s Profile
- Current Projects
- Strategic Aspects on CAE and HPC
- CAE Roadmap and Conclusion

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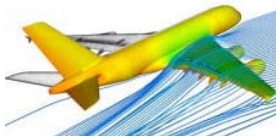
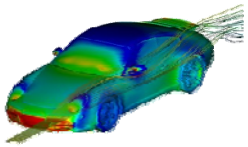
asc(s e.V. Profile

asc(s is the Second of Three Planned Competence Centers





Braunschweig Bremen	Stuttgart	Karlsruhe
Center for Computer Applications in Aerospace, Science and Engineering C²A²S²E *Foundation 29.05.2007*	**Automotive Simulation Center Stuttgart** asc(s) Automotive Simulation Center Stuttgart *Foundation 07.03.2008*	**Energy Solution Center Karlsruhe** EnSoC *Foundation 15.12.2009*
Land Niedersachsen, DLR, Airbus	Daimler, Opel, Porsche, Karmann, Altair, CADFEM, CD-adapco, DYNAmore, DS SIMULIA, Engineous, ESI, INTES, SFE, Cray, IBM, NEC, Univ. Stuttgart, FKFS, HLRS, SIT, VDC	Karlsruher Institut für Technologie (KIT), EnBW Energie Baden-Württemberg AG, Siemens AG, SAP AG, T-Systems SfR GmbH, Hewlett-Packard Deutschland GmbH

High Performance Computing (HPC)

CO_2 -Reduction / Consumption, Reduced Noise Emission
Reduction Product Development Time (CASE, asc(s)

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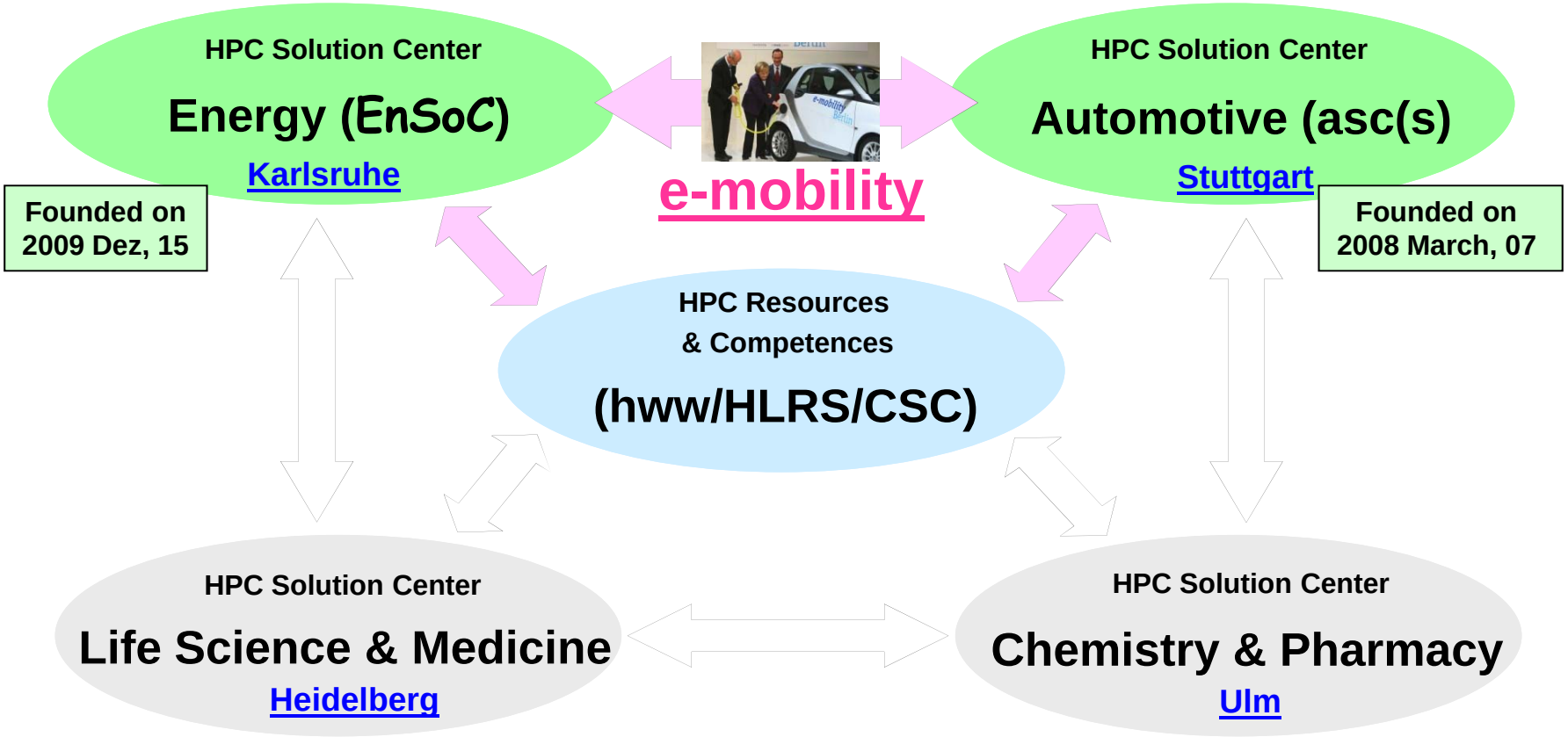
Intention: Through networking of the Solution Centers synergies are generated.



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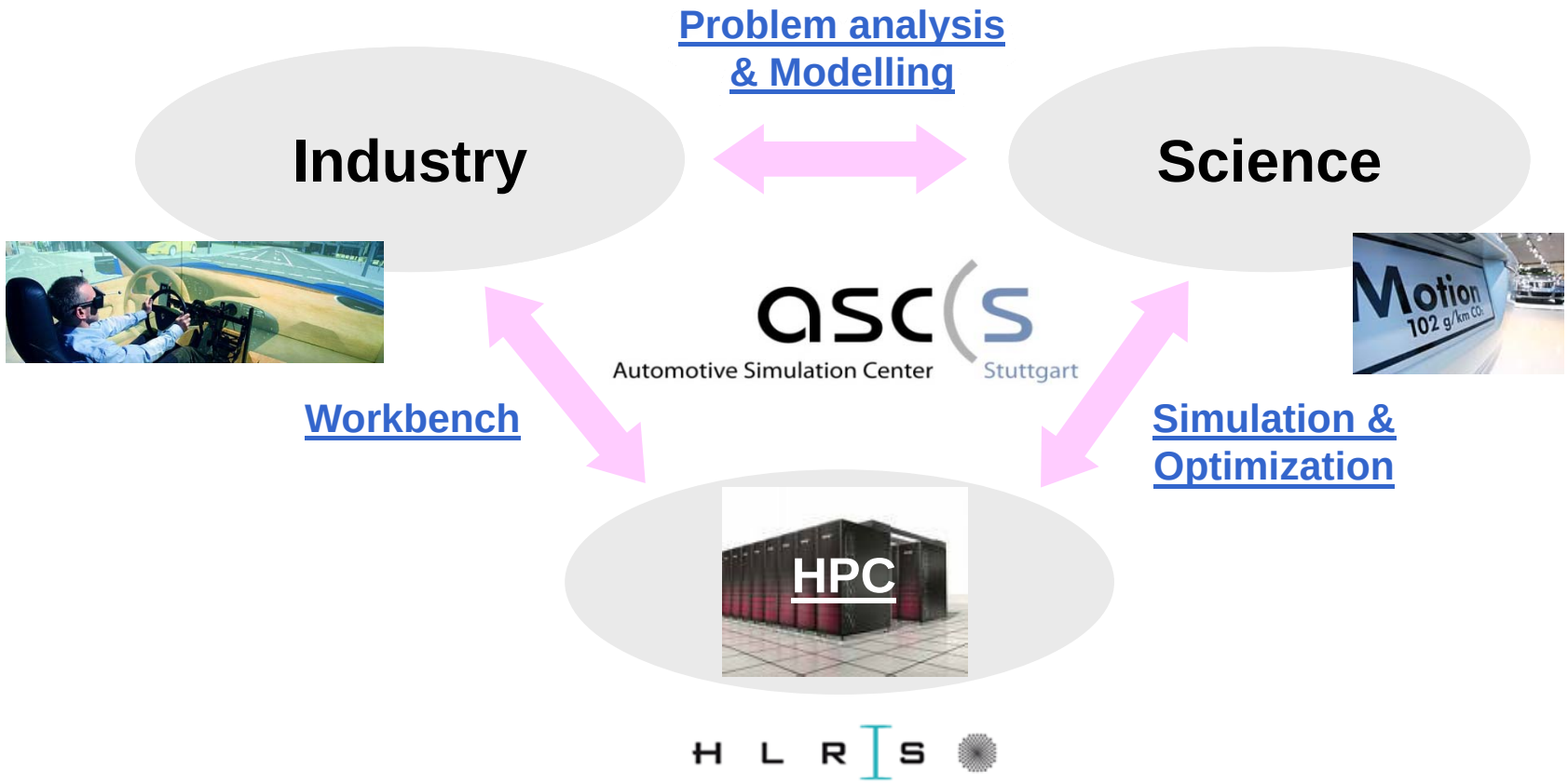
Co-operation model of the asc(s



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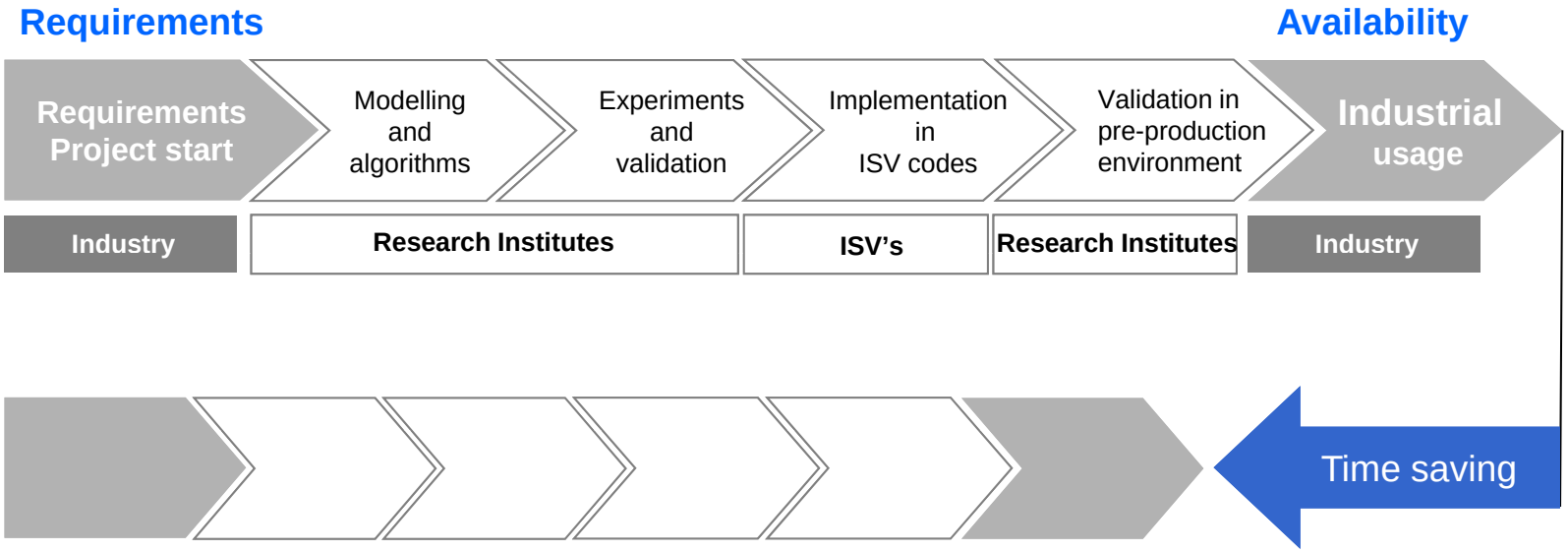
Goals of the asc(s

- Supercomputer Simulation in Automotive Industry
- Rapid availability in the form of commercial codes
- Shortening of time to solution



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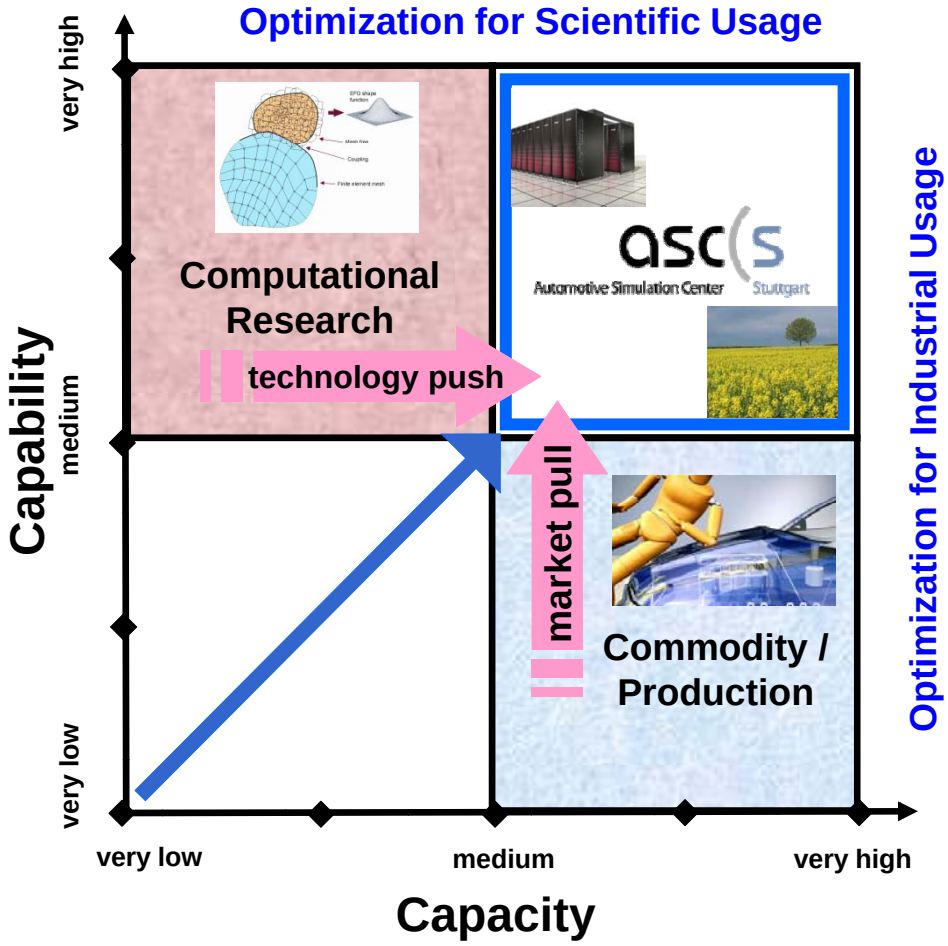
asc(s e.V. Profile

Positioning of asc(s on the HPC "Capability versus Capacity"



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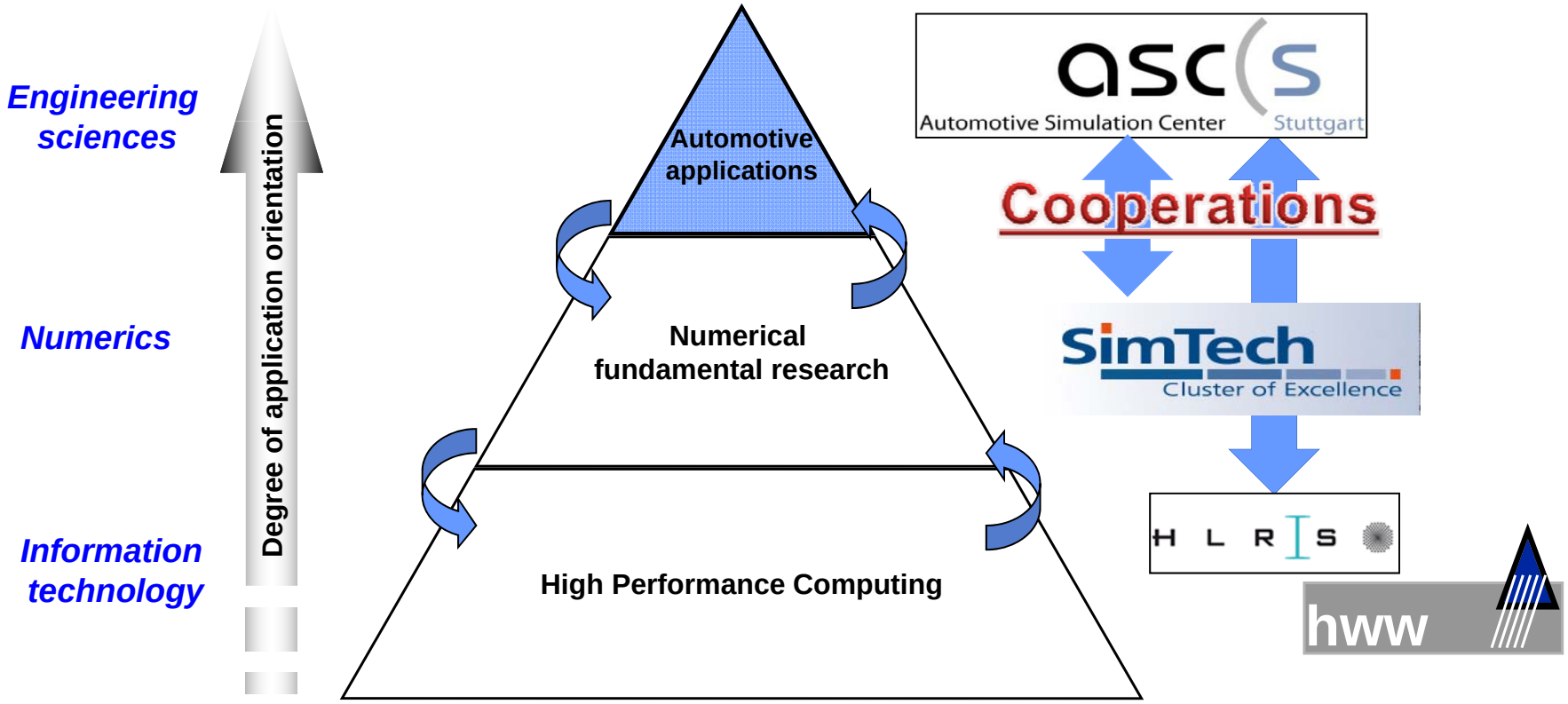
asc(s e.V. Profile

The asc(s within the HPC simulation pyramid



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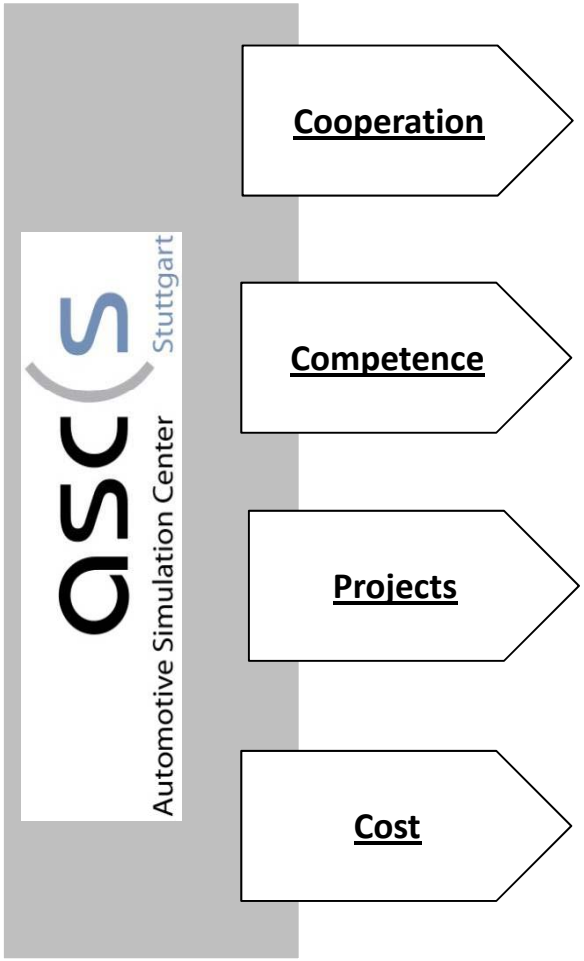
asc(s e.V. Profile

The asc(s business model



Cooperation between science and industry through sustainable partnerships and collaborations in the industrial pre-competitive collaborative research area. This ensures a rapid economic availability of research results with high quality and provides new impulses for product development.

Avoidance of fixed costs with the highest expertise by forming a Competence network for solving the specific project task with the best experts from home and abroad. The asc (s assumes the application of external funding and the complete project management.

Active introduction of project ideas by the members. The prioritization is done by the board of the asc (s, with the support of the Scientific Advisory Board.

Project implementation at optimal cost due to:

- non-profit status of the asc (s
- generally free provision of licenses issued under the project by asc (s members from the CAE field
- absorption of costs of supercomputing for subsidized projects by the University of Stuttgart
- start-up funding from the Land BW and the University of Stuttgart

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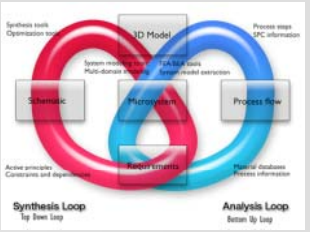
Current Projects

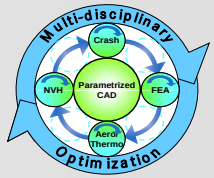
First Projects will be launched at asc(s in the following topics

- **Optimization of mixture formation**

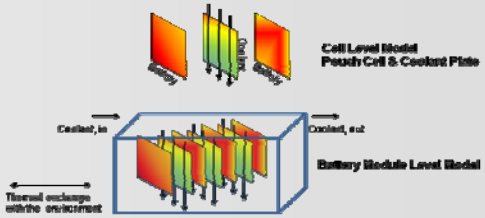
  (Multi-Physics, Multi-Domain,
  Multi-Scale and Multi-Stage Simulations)



- **Multi disciplinary optimization (MDO)**

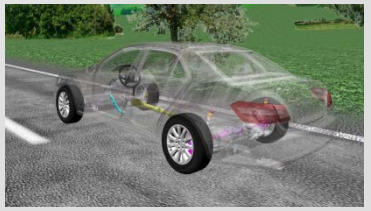


- **Simulation technologies for Hybrid (HEVs) and pure electric vehicles (PEVs)**



- **CAE Solving technologies**

  (e.g. Robustness, MBS-FEM coupling…)



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Current Projects

Project clusters of the asc(s

New

Vehicle Drive train

Flow motion and combustion optimization (MDO) in engines

Vehicle Structure

Weight and cost optimization (MDO) of vehicle structures

Vehicle Physics

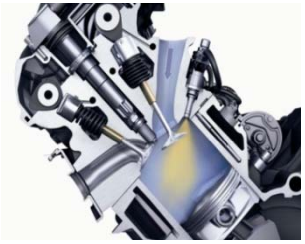
Thermal behavior simulation of hybrid and electric vehicles

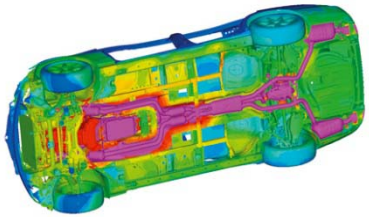
Vehicle ICT

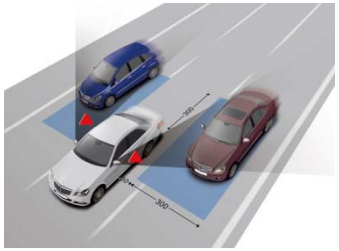
Optimization of traffic flow and driver assistant systems

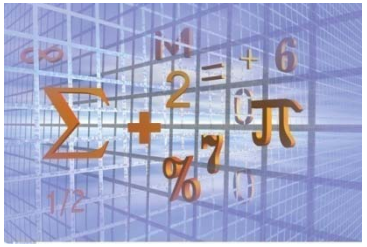
Numerics & Mathematics

Optimization of CAE Solving technologies









For more information, see: www.asc-s.de

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Current Projects

Simulation of the fuel post-injection and the following oxidation within the Diesel Oxidation Catalyst

Aim and challenge of the project:

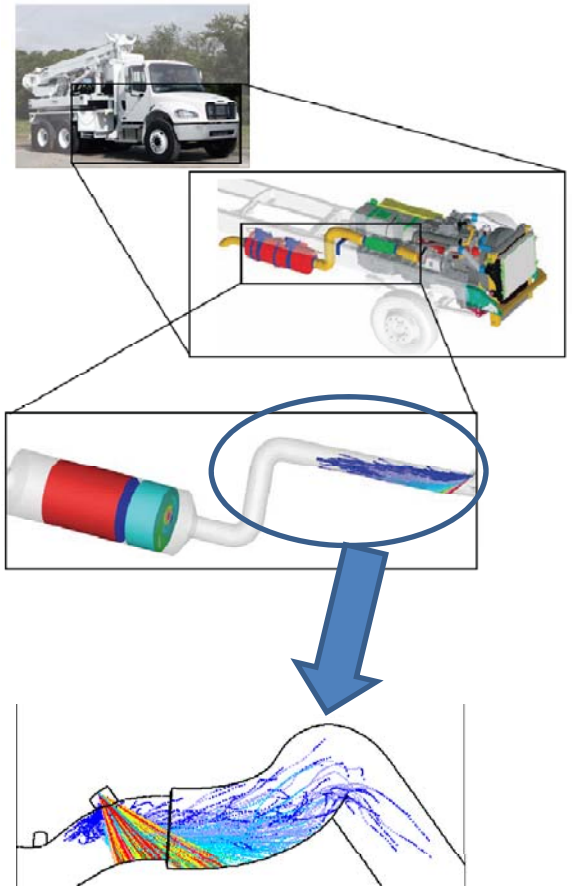
- Modeling of multi-component fuels;
- Creation of conjugate heat-transfer models between the wall of the exhaust duct and the multiphase flow;
- Implementation of the kinetic reactions describing the oxidation process within the catalyst.

Work packages:

WP 1: Bibliographic research
WP 2: Creation and implementation of evaporation-models for multi-component fuels
WP 3: Creation and implementation of a lean model for conjugate heat-transfer between wall, airflow and liquid film
WP 4: Implementation of the oxidation's kinetic reactions
WP 5: Simulation of a real case, validation with measurements
WP 6: Numerical optimizing of the post-injection
WP 7: Project-review and documentation

Project-team:

Daimler, Porsche, CD-adapco, ITLR, HLRS, asc(s



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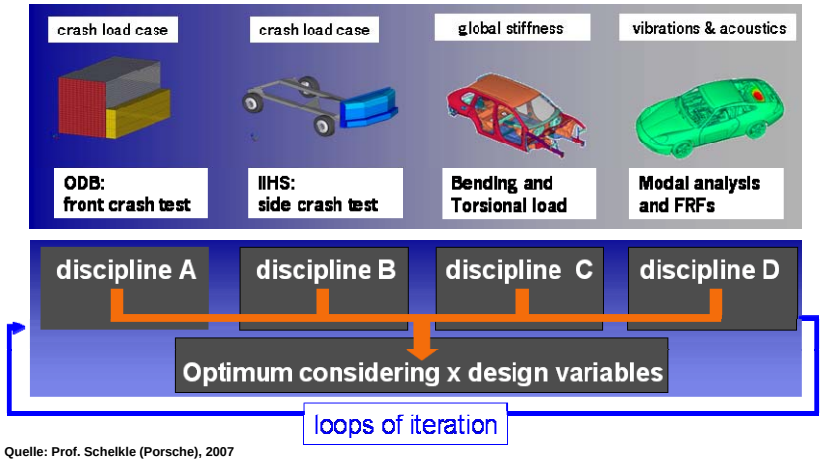
Current Projects

Multi-disciplinary Optimization (MDO) of Vehicle Structures

Aim and challenge of the Project:

A MDO must run:

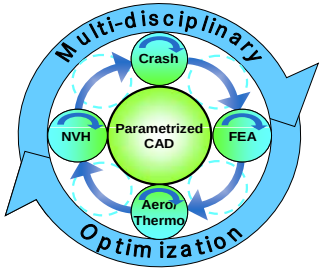
- Parallel to other simulation runs
- In normal cases in an inhomogeneous IT-environment
- With restricted number of licenses
- Partially in normal workstations for Pre-/Post-Processing and in a Cluster
- Robust despite hundred of jobs.

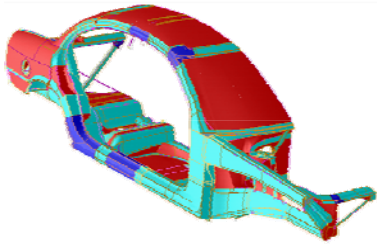


Quelle: Prof. Schelkle (Porsche), 2007

Work packages:

WP 1: Methodology*
WP 2: CAE-Process Chain
WP 3: Pre-Processing
WP 4: MDO-Analysis*
WP 5: Post-Processing
WP 6: Use-Cases
WP 7: Industrial Transfer*
WP 8: Project Coordination and Supervision
WP 9: Project Conclusion and Review
* The red WPs are actual not being processed





Project-team:

Daimler, Porsche, Altair, DYNAmore, Engineous, HLRS, asc(s

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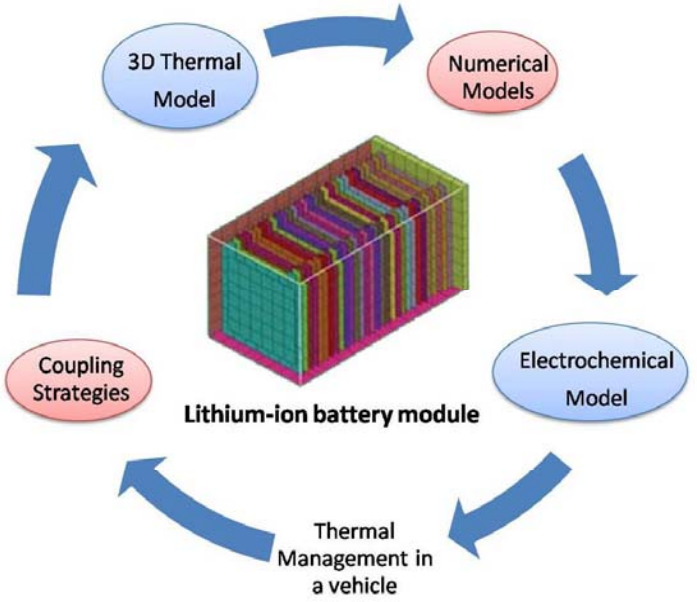
Current Projects

Development and Validation of Thermal Simulation Models for Li-Ion Batteries in Hybrid and Pure Electric Vehicles

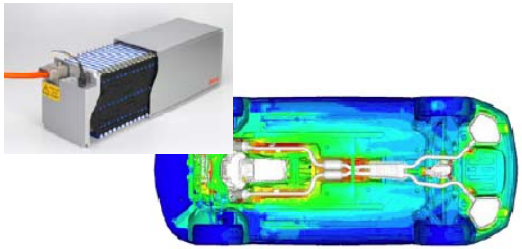
Aim and challenge of the Project:

- 3D calculation of the heat path from the cell to the battery cooling system and vehicle (cooling optimization)
- Thermal behavior of the battery system running under:
  - maximum electrical and thermal load (thermal management application)
  - a drive cycle energy management application (energy management application)



Work packages:

WP1: Project management
WP2: Hardware and Model Alignment
WP3: Experiments
WP4: Parameterization
WP5: Model Development
WP6: Data Management, Computations and Production Runs
WP7: Verification and Validation



Project-team:

Daimler, Porsche, Opel, Behr, Battery Design, CD-adapco, asc(s

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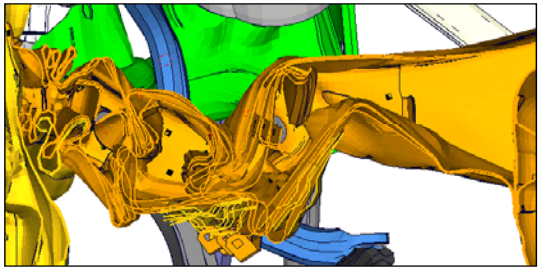
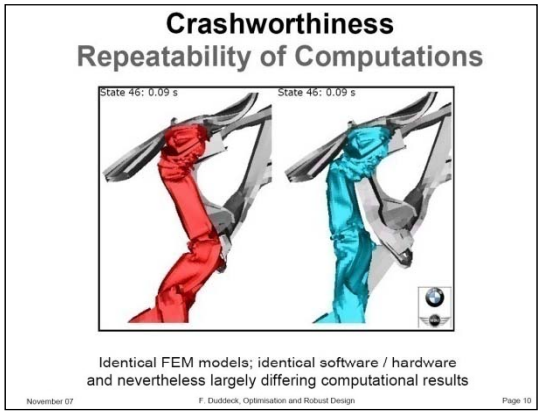
Current Projects

Reduction of numerical sensitivities in crash simulation on HPC-Computers

Aim and challenge of the Project:

- Elimination or minimization of the numerical noise
- Thus predictable crash simulations are possible
- Comparison of variants are possible
- Automated optimization would be more effective
- A better computational structural dimensioning in regard to lightweight construction is possible





Work packages:

WP 1: Cause Analysis
WP 2: Modelling
WP 3: Geometry and Discretization
WP 4: Numerics und Simulation
WP 5: Problems of the software technical implementation
WP 6: Validation
WP 7: Optimization

Project-team:

IBB, SFI, HLRS, asc(s

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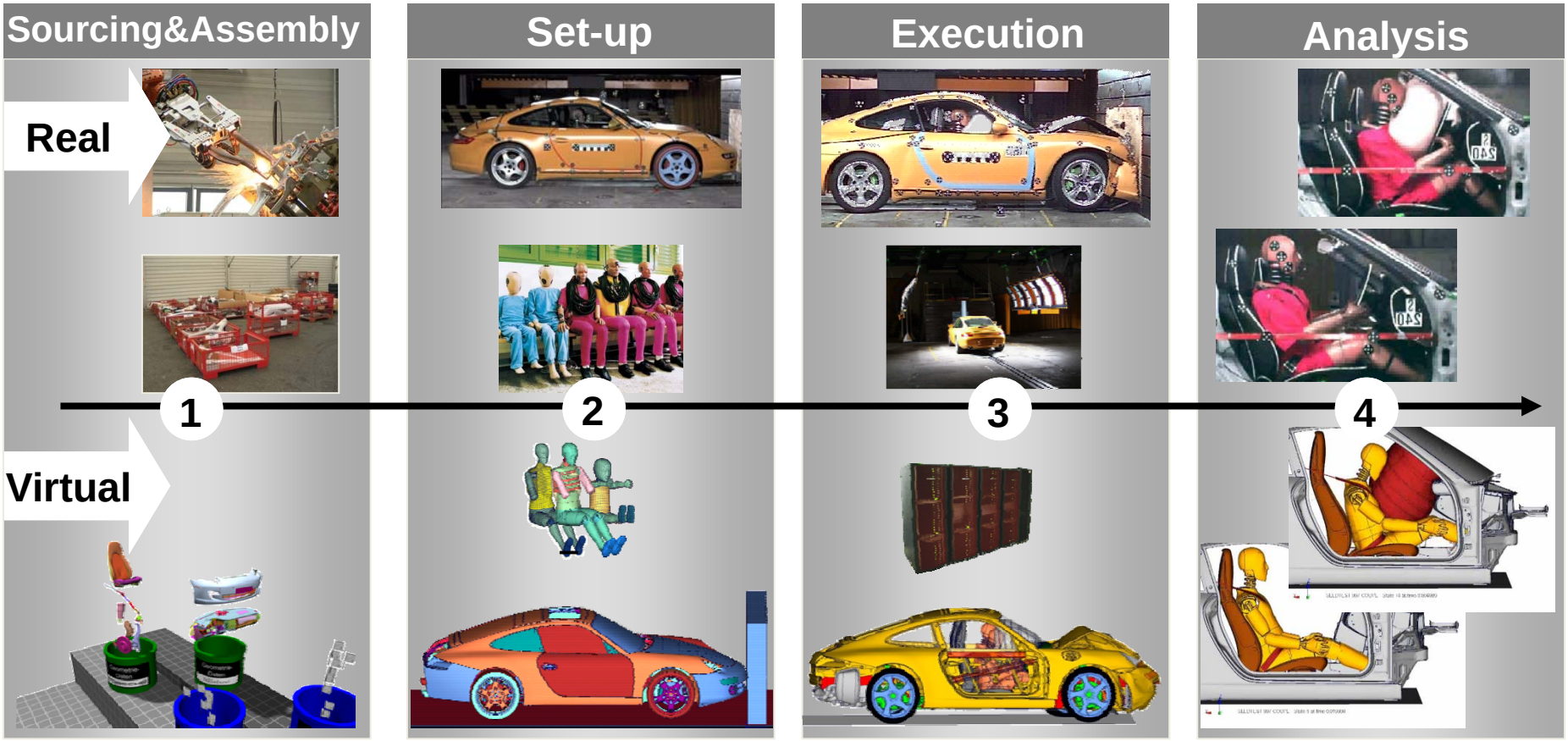
Strategic Aspects

From the Road to Test bench and Computer

Crash testing as example



Source: Dürheimer (Porsche AG) 2008

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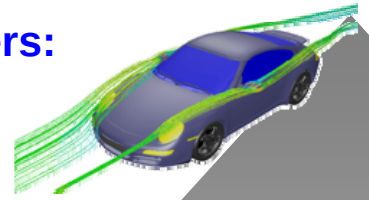
Strategic Aspects

Examples of Digital Prototypes and IT Requirements

Demands on supercomputers:

- Highly scalable,
- Long run times

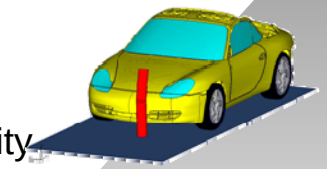


Global CFD

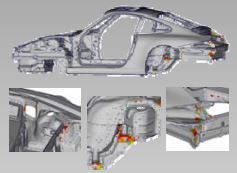
Global crash

Big workstations:

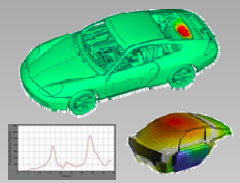
- I/O intensive,
- Large memory,
- Limited in scalability



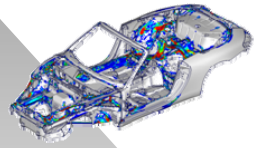
Pedestrian protection



Durability

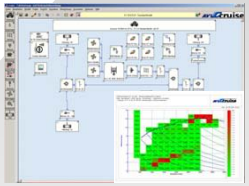


NVH acoustic

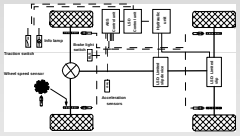


Global stiffness

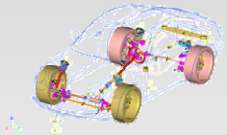
Desktops:



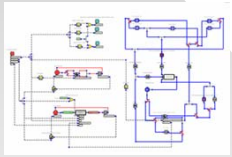
Performance and fuel consumption



Global control system



Multi-body



Global thermal

Source: Dr. Wierse (Porsche AG), 2007

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Strategic Aspects

Statistic simulation runs (Panamera)	Concept phase	Definition phase	1st. hardware loop	2nd. hardware loop	Series	Total simul. runs
Crash full vehicle (LS-DYNA)	**200**	**250**	**800**	**1600**	**1500**	**4350**
Occupant protection (LS-DYNA)	0	80	350	250	300	**755**
Greenhouse (LS-DYNA)	200	500	1950	2050	2000	**6700**
Pedestrian safety (LS-DYNA)	500	800	3000	4600	3200	**12100**
Stiffness full body (PERMAS)	100	310	190	220	30	**850**
Fatigue (FEMFAT)	0	50	260	220	80	**610**

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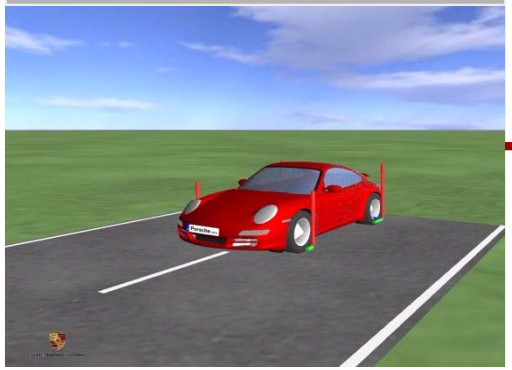
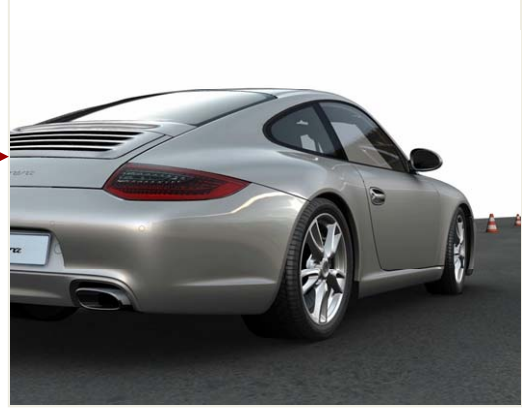
CAE Roadmap

In order to simulate the experience of the future product, new visualization and real-time simulation technologies are being introduced

Digital prototype: Chassis control model



Photorealistic real-time visualization



Real-time simulation

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CAE Roadmap

Driving dynamic simulation results of a Porsche 911 Carrera – Comparison between the standard version and the S-version

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CAE Roadmap

Computational Fluid Dynamics Simulation around an through the Porsche 911 Carrera S

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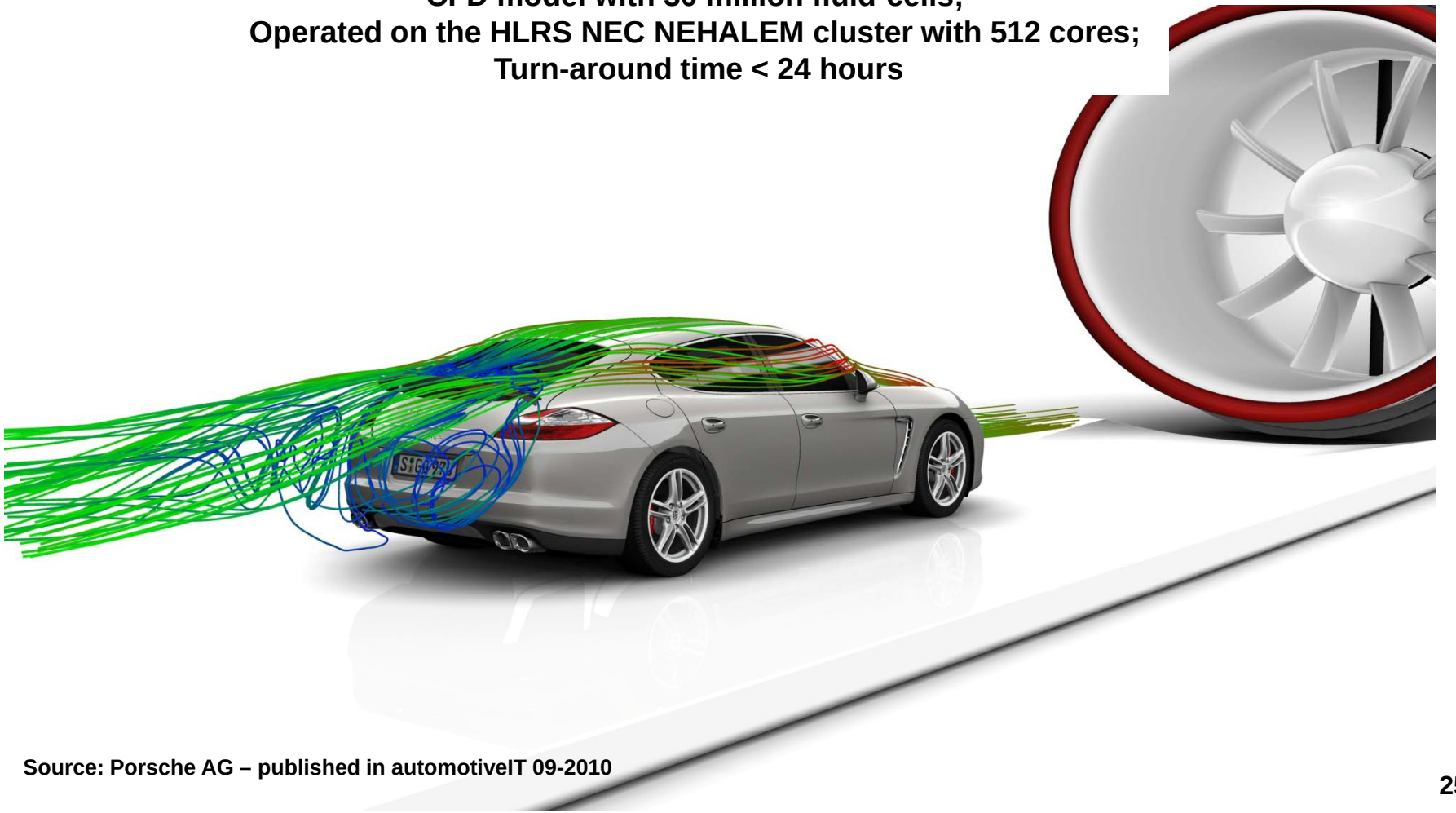
CAE Roadmap

Computational Fluid Dynamics Simulation for the Porsche Panamera

CFD model with 30 million fluid-cells;
Operated on the HLRS NEC NEHALEM cluster with 512 cores;
Turn-around time < 24 hours



Source: Porsche AG – published in automotiveIT 09-2010

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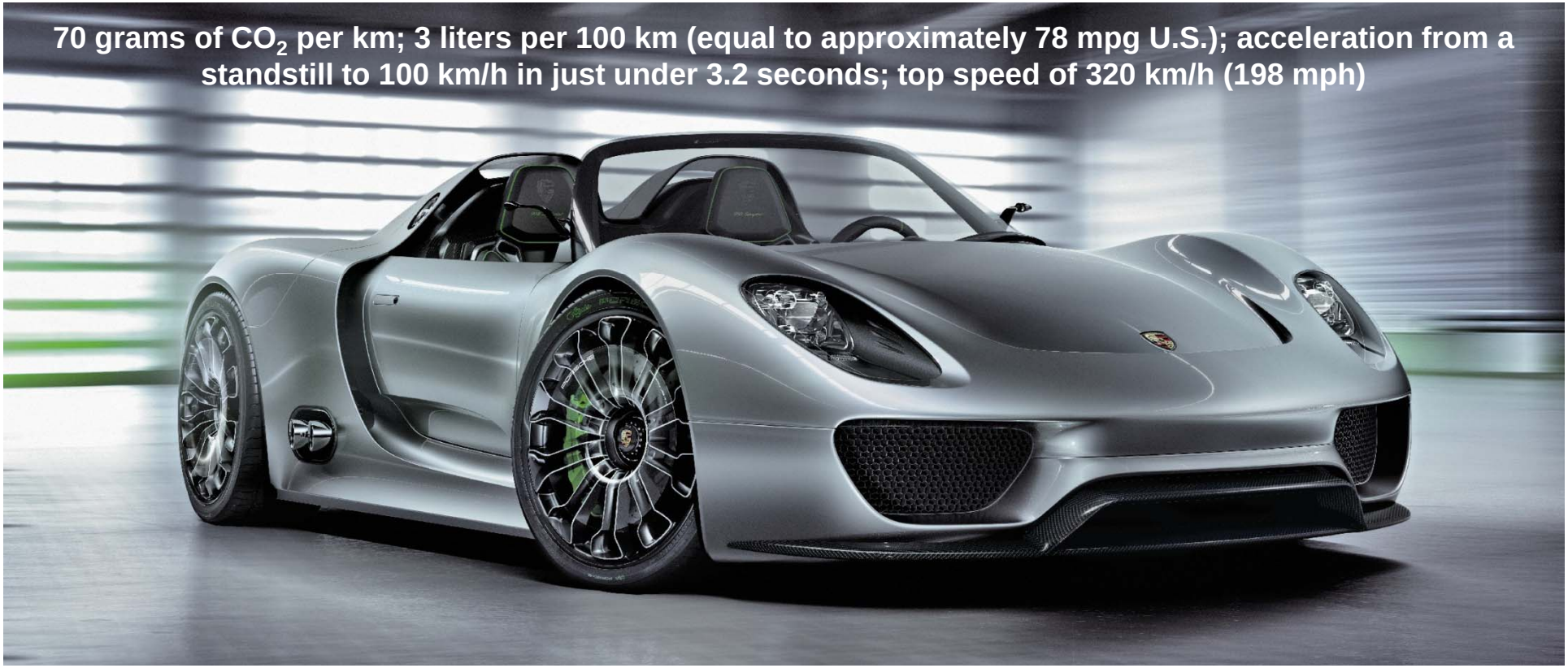
Conclusion



Porsche Super Sports Car 918 Spyder
Highly efficient and fast: Concept car with Plug-in-Hybrid Technology

Thank you for your attention.
If you have any questions, please go ahead now.

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